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STUDIES ON SILAGE IN PUERTO RICO. I. METHODS OF ENSILING AND RESULTING QUALITY OF MERKER, CANE TOPS AND PARA GRASS SILAGES

By L. RIVERA BRENES,[1] F. MARCHÁN,[2] and E. DEL TORO.[3]

INTRODUCTION

Recurrent deficiencies in both quantity and quality of forage crops and the use of large amounts of costly concentrate feeds are among the major factors responsible for high costs in milk production in Puerto Rico. A wasteful use of forage is the inevitable result of the present method of forage cropping. In the areas where soilage forage is used, it is nearly impossible to feed grass at the optimum stage of maturity and at the same time avoid both shortage during the dry season and over-abundance during favorable growing periods. In pasture areas the problem is even more acute, requiring a large acreage for pasture and also the use of large quantities of concentrates during the dry-weather months in order to keep the cattle alive.

Furthermore, under present methods of forage cropping land is not economically used. Sufficient land must be set aside to provide minimal quantities of forage of any quality during dry seasons. The economy of Puerto Rico will profit if these lands were freed to be put to a more intensive use.

Proper methods of storage are necessary to provide sufficient forage of good quality during the whole year. The making of hay is difficult due to frequent rains during the growing seasons and because the grasses now used are too thick-stemmed to dry and handle as hay, unless they are chopped and dried artificially. Because of the climate, the crops now grown, and the availability of inexpensive molasses, the preservation of grasses as silage offers a rational solution to the problem.

At present there are few silos in use in Puerto Rico. Information concerning the usefulness of presently grown crops, methods of making silage of these crops, and the economic value of silage in Puerto Rico is meager.

It was the purpose of this study to secure information concerning the possibility of making silage of grasses grown in

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Puerto Rico, the best methods to be used, the changes and losses that take place in the silo, and the quality of the resulting silages as mesaured by chemical analysis, palatability and appearance.

Literature Review

The literature concerning the preparation of silage and the losses encountered in silage are reviewed by Woodward [10] et al and LeClerc.[6]

May [7] erected the first silo in Puerto Rico at the Federal Experiment Station, Mayagüez. He secured good results using corn as ensilage but poor results with cane tops, Guinea grass and Para grass (Malojillo).

Experimental

Six concrete silos 7½ feet in diameter and 15 feet high, each having a capacity of 7 to 10 tons of fresh forage were used. A series of holes was made in the walls at random points at 4, 6 and 10 feet from the top. These holes were fitted with 2-inch capped pipes and were used for drawing samples for chemical analysis.

FIGURE 1.—Experimental Silos. Capacity 7 to 10 tons of green forage.

Grasses were cut by use of a large-size Gehl cutter and were blown into the silos in the usual manner. At the same time, molasses was added by means of a pump attached to the silage cutter and its rate of addition regulated by means of a valve. Water was added by diluting the molasses, care being taken to insure the addition of the correct amount of molasses.

One man was used to distribute the cut grass and to trample it according to the specifications of each trial. The amount of fresh grass placed in each silo was estimated by averaging the weights of two ox carts of grass and multiplying the average by the number of carts used.

Para grass (*Panicum barbinode*), cane tops (*Sacharum officinarum*) and Merker grass (*Penissetum purpureum* var. *Merkerie*), were the forages used. Special emphasis was placed on the latter due to its increasing importance as a crop in Puerto Rico. Observations were made on the factors affecting the quality and quantity of the silage. Such factors were: length of chopped grass, moisture content of the grass, thoroughness of packing, and the maximum length of time which could elapse between partial fillings of the same silo.

Chemical analyses of the fresh grass (plus molasses when it was added) and of the silage were made from random samples of the material. The bag method was used for analysis in one trial. Moisture was determined by placing samples in an oven set at 70°C and equipped with a turbo blower. The pH was measured with a MacBeth pH meter. Other analyses were made according to the official methods of the Association of Official Agricultural Chemists.[8] Calculations of the percentage of total nutrient losses were made by using the approximate amount of nutrients in the ingoing dry matter (total) and the amount of nutrients in the dry matter that was recovered as edible silage.

Factors considered in the evaluation of the quality of the silage were: pH, odor, color and palatability. The latter was tested by a series of feeding trials in which silage and soilage of the same quality were used. All silos were opened thirty days after filling.

Nine silos were filled: six with Merker grass with ten per cent molasses, two with Para grass with five and ten per cent molasses, and one with cane tops to which no molasses was added.

The forage was chopped ½ inch long. This length of cut ½ inch or shorter is recommended to insure packing. In silo No. 1 a man was used to level and trample the material at intervals of three ox carts chopped; in the rest of the silos the man was kept leveling and trampling constantly.

Water was added to all silages except to No. 9, at a rate of 3 to 5 per cent of the approximate weight of the forage. The amount varied according to the operator's judgment of dryness of the material.

Results and Discussion

In Table 1 the approximate total weight of material put into four of the experimental silos is shown.

TABLE NO. 1

APPROXIMATE TOTAL WEIGHT OF MATERIAL PUT INTO FOUR OF THE EXPERIMENTAL SILOS

Silage No.[1]	Number of ox carts of grass used	Ave. wgt. of two ox carts lbs.	(Approximate) total weight of forage	Molasses Per Cent	Total wgt. of molasses	Amount of water added lbs.	Water added by wgt. of forage Per Cent	Total wgt. of material
1	12	1,488	17,856	10	1,785	799	4.50	20,440
4	10	1,850	18,500	10	1,850	650	3.50	21,000
5	10	1,187	11,870	10	1,187	543	4.50	13,600
9	10	1,089	10,890	10	1,210	000	0.00	12,100

[1] Merker grass used.

Due to the fact that the molasses pump was adjusted to spray at a rate of ten per cent when the chopper was fed continuosly, it appears that the total amount of forage calculated is approximately accurate. The fact that there was no bottom spoilage in any of the silos indicates that the amount of water was not excessive.

Chemical analyses of the ingoing grass and the resulting silage are presented in Table 2.

TABLE No. 2

PROXIMATE ANALYSES OF THE GRASSES PLUS MOLASSES AND THE SILAGES

No. of silo	Grass	Date Ensiled	No. of Samples	Analyses							
				Molasses	Moisture	Dry matter	Ash	Crude protein	Ether extract	Fiber	N. F. E.[4]
				Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
1	Merker	12-6-46	1		76.30	23.70	10.59	9.47	2.37	31.55	46.02
	Silage		2	10	76.70	23.30	11.36	9.53	3.52	32.22	43.39
2	Merker	3-13-47	2		76.25	23.70	6.51	5.13	2.25	35.54	50.58
	Silage		7	10	74.23	25.77	8.51	5.37	2.90	33.55	49.67
3	Merker	3-18-47	2		72.20	27.80	6.55	5.01	2.14	36.53	49.77
	Silage		7	10	72.76	27.24	8.30	5.21	2.70	33.15	50.64
4	Merker	6-25-47	11		82.40	17.60	11.25	5.88	2.13	33.56	47.18
	Silage		8	10	79.60	20.40	12.39	6.12	2.25	27.68	51.56
5	Merker	7-31-47	7		73.66	26.34	10.23	5.26	2.23	32.53	49.75
	Silage		8	10	72.72	28.00	13.55	6.28	2.41	28.08	49.88
6	Cane tops	3-7-47[1]	2		77.70	22.30	9.03	6.37	2.36	31.71	50.53
	Silage		7		76.86	23.14	8.93	6.75	1.74	34.76	47.82
7	Para grass	11-26-47	5		73.24	26.76	15.75	9.10	1.56	24.76	48.83
	Silage		6	10	71.89	28.11	18.28	8.54	1.27	25.37	46.54
8	Para grass	11-28-47[2]	5		78.42	21.58	15.93	7.84	1.22	27.50	47.49
	Silage		6	5	79.07	20.93	16.42	6.64	1.15	30.40	45.39
9	Merker	11-4-47[3]	5		69.78	30.22	10.40	7.30	1.62	34.19	46.49
	Silage		5	10	67.51	32.49	10.72	6.71	1.84	33.49	47.24
(9)	Bag sample		1		69.10	30.90	10.83	7.06	1.71	34.58	45.72
	Silage		1	10	68.10	31.90	10.19	5.81	2.01	36.06	42.93

[1] No molasses used.
[2] Five per cent molasses.
[3] No water was added to this silage.
[4] Nitrogen free extract.

Chemical composition of forage grasses has been shown to vary with the stage of maturity, soil conditions and climate.[3] Young plants are characterized by their high protein content and high digestibility of their dry matter. The earlier the crop is harvested, the higher will be the protein and moisture content, but too early a harvest of any crop will reduce the tonnage.[4] In general, the same rules may apply as regards time of cutting for silage as for soilage. The feeding value of silage will depend upon the feeding value of the fresh material, and the conditions under which it is ensiled.[1]

As all grasses are comparatively low in protein content, the soundest procedure would be to harvest the crop at a point where the maximum tonnage can be obtained with the least reduction in quality. In Puerto Rico, Merker grass is in good cutting condition just before bloom: 60 to 80 days old. Variations will arise due to farming practices and changes in weather conditions. Para grass is somewhat different; before bloom it is too short for cutting. The best time to cut is right after blooming, except for very fertile soils where good growth will permit earlier cutting. The time will vary between 50 to 70 days. For cane tops, the farmer has to wait until the sugar cane harvest.

The proximate total losses for Merker silage are presented in Table 3.

TABLE No. 3

APPROXIMATE LOSSES IN MERKER SILAGE PRESERVED WITH TEN PER CENT MOLASSES

Silage No. and date ensiled	Grass, molasses and water	Dry matter	Total Dry matter	Intangible loss	Loss	Edible silage	Spoiled silage	Loss	Total loss
	Lbs.	Per Cent	Pounds	pounds	Per Cent	Pounds		Per Cent	Per Cent
12-6-47									
1- Ingoing	20,440 00	23 70	4,844 28	739 10	15 67				
Outgoing	17,553 00	25 30	4,085.19			16,213 00	1,140 00	6 50	22 17
6-25-47									
4- Ingoing	21,000 00	17 60	3,696 00	365 50	9 89				
Outgoing	16,326 00	20 40	3,330 50			15,336 00	990 00	6 06	15 95
7-31-47									
5- Ingoing	13,600 00	26 34	3,582 24	277 12	7 74				
Outgoing	11,804 00	28 00	3,305 12			10,833 00	971 00	8 23	15 97
11-4-47									
9- Ingoing	12,100 00	30 22	3,656 62	258 17	7 06				
Outgoing	10,400 00	32 49	3,398 45			9,620 00	840 00	8 03	15 09
Bag Sample 11-4-47									
Ingoing	471 50[1]	30 90	145.70[1]	4 67[1]	3 20				
Outgoing	442 10	31 90	141 03						

[1] Weight in grams.

The importance of good packing was indicated by the results of total losses in silage No. 1 as compared with the other three. The larger losses in silo No. 1 were probably due to the fact that leveling and tramping were done at intervals instead of having a man constantly in the silo, as in the other three; packing was not as good as in the others.

Table 4 presents a summary of total nutrient losses compared to the losses reported by other workers in the field.

TABLE NO. 4

SUMMARY OF NUTRIENT LOSSES IN PERCENTAGE LOSS OR GAIN

	Dry matter	Ash	Crude protein	Ether extract	Fiber	Nitrogen free extract
Silo No. 1	−22.02	−16.34	−21.56	−15.83	−20.36	−26.47
Silo No. 4	−15.40	− 6.82	−11.85	− 10.57	−23.17	−13.86
Silo No. 5	−17.50	+ 7.66	− 1.51	− 10.84	−28.79	−17.29
Silo No. 9	−14.52	−14.52	−21.43	− 2.92	−16.27	−13.14
Bag sample (9)	− 3.30	− 8.94	−20.40	+ 13.65	+ 8.98	− 9.12
Le Clerc (6) citing Henry and Wall and Woodman and Amos[1]	− 5.8 to −18.1	+ 3.1 to − 6.8	+ 2.0 to −12.2	+ 59.0 to −122.0	+ 0.90 to −11.80	−16.20 to −24.90
Ragsdal and Turner (9)	− 2.1 to −18.1	−11.7 −15.7	+ 5.1 to −38.4	+ 49.4 to − 20.3	+ 6.70 to −14.6	− 5.8 to −22.5

[1] Using bag samples.

Results obtained on total losses and nutrient losses are within the range of the findings of other investigators [2, 3, 6, 9]. There is a wide variation in the percentage of losses or gains. It is apparent that appreciable quantities of nutrients are lost and that the losses silage undergoes depend upon the size of the silo, amount of silage and on the methods and techniques used.

The results obtained on pH values in three of the experimental silos are presented in tables 5 and 6.

TABLE No. 5

pH VALUES AT DIFFERENT INTERVALS AND AT DIFFERENT LEVELS. MERKER GRASS, TEN PER CENT MOLASSES

Silo Number	Interval from ensiling days	Distance from top feet[1]	pH values
No. 9 Filled 11-4-47	6	10	3.7
		6	3.8
		4	4.0
	9	6	3.9
		4	4.0
	13	10	4.1
		6	4.2
		4	4.4
	21[2]	10	4.3
		6	3.8
		4	4.0
Mean			3.95

[1] Samples taken through the holes in the sides of the silo at those levels.
[2] No more samples were taken from there on due to mold contamination around sampling holes.

TABLE No. 6

PH VALUES AT DIFFERENT INTERVALS AND AT DIFFERENT LEVELS MERKER GRASS TEN PER CENT MOLASSES

Silo Number	Interval from ensiling days	Distance from top feet[1]	pH values
No. 5 Filled 7-31-47	35	2.0	4.1
	37	3.0	4.1
	39	5.0	4.2
	43	6.0	4.0
	46	7.0	4.3
	50	9.0	4.0
	53	10.0	3.8
	57	13.5	4.1
Mean			4.05
No. 4 Filled 6-25-47	71	2.0	4.3
	72	3.0	4.3
	75	5.0	4.0
	79	6.0	4.1
	82	7.0	4.6
	86	9.0	3.8
	89	10.0	3.6
		13.5	4.2
Mean			4.01

[1] Samples obtained as the silage was taken out for use.

The pH values obtained indicate that Merker silage was preserved in excellent condition. These values are in agreement with the findings of other investigators which give the same range of pH values for good silage [3, 6, 10].

Due to the natural characteristics of Merker grass, which has light leaves and hard bulky stems; Para grass, which has light and hollow stems; and cane tops, which are bulky and nearly always quite dry; chopping to ½ inch or less, the addition of some water, especially toward the top of the silo, and continuous tramping are essential factors to be considered when ensiling in order to get good packing and prevent excessive losses (especially top spoilage and spoilage toward the walls of the silo).

Wilting is not advisable for the reasons pointed out above; the material will become too light to attain good packing, even with tramping. In addition, the hot tropical sun will destroy a large portion of the carotene and part of the protein during the wilting period. It is true that too much moisture will cause some spoilage in the bottom of the silo, but too little moisture is much more serious than too much.

Merker grass plus ten per cent molasses produced a very palatable "green, fruity" [6] silage with a pleasant molasses odor. Para grass with five or ten per cent molasses produced a "sweet, dark-brown" [6] silage of a much lower quality than Merker silage, as regards color, odor and palatability. Of the two Para grass silages, the ten-per-cent molasses silage was more palatable and had a more pleasing odor than the five-per-cent silage, as indicated by the fact that the cows consumed the former more readily. Para grass has the disadvantage that dirt is nearly always found in it due to its habit of growth: close to the ground and in swampy places. This, without doubt, affects quality adversely.

Cane tops were ensiled satisfactorily without molasses. They produced a coarse silage, lower in quality than Merker. Cattle ate it and because cane tops are harvested during the dry season, the silage makes a good substitute for Merker or Para grass soilage and other pasture crops which are affected by drought. A large quantity of sugar cane is grown in the Island and cane tops are very easy to get during the harvest season that lasts from three to five months.

Para grass and cane tops were ensiled satisfactorily, contrary to the findings of May [7] who used a very dry material adding no water. Very poor packing was probably attained.

Molasses has been considered one of the best, if not the best, preservative for silage [1, 4, 6, 10]. In Puerto Rico, where sugar

cane is the main cash crop, molasses is cheap, a little less than two cents a pound, and easy to get. Many of the dairymen are also sugar cane growers and have a share of the molasses produced from their cane. They are, therefore, in a very favorable position to face the scarcity of pasture and soiling crops during the dry season by erecting silos of adequate size for their herds and preserving grasses with molasses.

Observations tend to indicate that, probably due to the warmer temperatures in Puerto Rico, the interval to resume filling the silo, after it is partly filled, should not exceed more than 24 hours because a very dense layer of molds will grow very rapidly on the uncovered portion. This moldy layer has to be removed before resuming the filling operation, consuming extra labor and increasing the loss of material.

Summary and Conclusions

Merker grass, Para grass and cane top silages were made satisfactorily using experimental silos 7.5′ × 15′. The commonly recommended techniques, except wilting, can be followed in Puerto Rico. Observations tend to indicate that the forage should be put into the silo within a few hours after cutting. Due to the natural characteristics of the native-grown grasses and of the excessively hot sun, wilting it not advisable: the material becomes too light to attain good packing and there is a probable reduction in the nutritive value.

Unless very heavy weights are put on top of the ensiled material (this is troublesome and costly in tower silos), water must be added to insure good packing especially toward the top of the silo. Experience will help to determine the amount of water to be added.

More detailed studies on total losses, nutrient losses and pH values were made with Merker silage. The results obtained were within the range reported by investigators in the United States.

Further observations tend to indicate too, that intervals between fillings should not exceed more than 24 hours to avoid excessive losses due to moldy silage. The tropical temperature seems to favor the rapid growth of molds.

With respect to odor, color, palatability and pH values, very good silage was obtained from Merker grass. Good cane tops

and Para grass silages were obtained too, but not of the same quality as Merker silage.

Molasses can be used as a preservative up to ten per cent. It increases palatability and nutritive value of the silage.

Results obtained with Merker grass silage probably apply to the other forage grasses in the Island, taking into consideration the results obtained in the present work as compared to the results obtained by others with grass and legume silages.

Acknowledgement

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THE UTILIZATION OF GRASSES, LEGUMES AND OTHER FORAGE CROPS FOR CATTLE FEEDING IN PUERTO RICO

I. Comparison of Guinea Grass, Pará Grass "Malojillo" and a mixture of Pará Grass and Tropical Kudzu as pasture crops

By LUIS RIVERA BRENES.[1]

INTRODUCTION

The success of the cattle industry in Puerto Rico is limited to a large extent by the lack of adequate sources of feed. Based on over 400,000 head of cattle, it is the second most important agricultural industry on the Island. In addition there are over 500,000 acres of cleared pasture land, which constitute about two fifths of the available arable land and whose efficient utilization is entirely dependent upon a well-managed cattle industry.

In Puerto Rico, the dairy cattle industry is somewhat regionalized. Intensive commercial milk production is mainly restricted to milk-shed areas sorrounding the urban centers. Dairy management is based on the use of Pará or "malojillo" (*Panicum purpurascens*) and Merker (Penninsetum purpureum. *var. Merkerii*) grasses cut for soilage with the supplemental feeding of mixed concentrate feeds.

Beef production is generally restricted to the grazing area of the southern coast and in reality is primarily a by-product of the production of workstock. Guinea grass is the prevailing pasture crop in this section.

In the mountainous areas cattle grazing is dependent upon miscellaneous grasses of low yield and little nutritive value.

Soil and climatic conditions on the Island are quite variable. In the north coastal region the rainfall is heavy and the soil is acid. In the south, the soil is alkaline and fertile, but its use is limited by a lack of adequate rainfall. The central portion of Puerto Rico has acid soils of low productivity and the climate is quite humid. The climate of the whole Island is characterized by periods of low rainfall in the winter and early spring and of abundant precipitation during the summer and fall. The dry period is much longer and more severe in the southern coastal region than in the other parts of the Island.

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Note: Mr. Juan Pedro Rodriguez, Associate Agronomist, was in full charge of the agronomic work required for this study.

The diet of the people of Puerto Rico is low in protein from animal sources. During 1944–45 [1] the per capita consumption of meat and fish, including imported products, was only 63 pounds. Twenty per cent of the 141 pounds of milk used per person was imported. For the same period, the per capita consumption of the United States was, on an average, 70 pounds of beef [2] and 440 of milk.[3]

Improved pasture and soilage crops should lower feed costs and increase the production of much-needed animal products, thus improving the diet of the Puerto Rican people to a considerable extent.

Literature Review

Information as to the best method of utilizing local grasses, legumes and other forage crops in the feeding of cattle in Puerto Rico is scant.

Axtmayer et al,[2, 3, 4] made studies on the nutritive value of some grasses and legumes grown at the Agricultural Experiment Station farm, which indicate that the grasses commonly used as forage crops are relatively low in protein content. Unpublished results obtained at the above-mentioned Station [9] have shown that when heifers were pastured on Guinea and Pará grasses they made better gains than when pastured on paspalum (*Paspalum hartwegianum*). Other results from the same project indicated that Merker and Elephant (*Pennisetum purpureum*) grass were not suitable for pasturing.

No experimental data have been published for Puerto Rico about the carrying capacity of any particular pasture previous to this work.

In the United States different methods of pasture evaluation were used until 1940, when a standard method was adopted by the Pasture Research Committee.[5]

Experimental

The forage grasses used in this grazing trial were: Pará grass, or malojillo (*Panicum purpurascens*), Guinea grass (*Panicum maximum*) and a mixture of Pará grass and tropical Kudzu (*Pueraria phascoloides*).

Pará and Guinea grasses are common on the Island. Tropical Kudzu, a legume native to Malaya, was introduced to the Island by the Soil Conservation Service in 1940. Telford [10]

reported that Kudzu is best suited to the parts of the Island having at least 50 inches of rainfall per year.

At the start of the trial the condition of all the grasses and Kudzu was satisfactory. The plots of Para, Guinea and Para-Kudzu mixture had been planted three, two and one years prior to the start of the trial.

The grasses and the mixture were planted in three blocks of three one-acre plots; each plot planted to a different forage. Every plot was subdivided into three lots, each one-third of an acre in area. The fencing arrangement of the plots allowed the animals in each lot access to shade, water and mineral mixture, (ad lib.). The position of each crop within a block was selected at random. The soil of the experimental field was a well-drained Fajardo clay. In order to decrease the acidity of the soil, lime was added to each lot to bring its pH to 6.5, two years before this study was initiated. No other fertilizer was used at any time.

Nine pure native heifers were used. They were uniform in age, six to seven months old, but varied in weight.

The heifers were weighed for three consecutive days at the beginning of the trial and for three consecutive days every time they were moved from one lot to the next.

One heifer was put in the No. 1 lot of each respective grass plot and was moved from one lot to the next in their own plot when any one of the lots in the entire experiment was grazed out. They were taken out of the experiment when they were of breeding age, 18 to 19 months old.

All lots that had some good roughage left at the time of moving the animals to the next lots were clipped with a "machete" and the residue weighed. Before clipping, samples were taken for analysis. Sub-samples of grass from the middle and the four corners of the lot were taken and a composite sample made from them. Moisture in the samples was determined by drying to constant weight at 70°C. In the analyses of all of the samples the methods used were those given by the Association of Official Agricultural Chemists.[8]

Computation of total digestible nutrients produced by the different grasses and the carrying capacity was made according to the recommendations of the Pasture Research Committee of the American Dairy Science Association.[5]

Analysis of variance and covariance were done according to the methods given by Love.[11]

Results and Discussion

Due to seasonal effects, the experiment was divided in three periods which were marked by the following: First period, with the three grasses under trial; second period, without the Pará grass; and the third period, where an extra heifer was put in the Pará grass-Kudzu mixture.

Results of the three grazing periods are presented in Table 1.

Table No. 1

WEIGHT GAINS IN PER GROUP, MEAN GAIN PER ANIMAL AND LEAST SIGNIFICANT DIFFERENCES

Grasses	No. of heifers	Initial weights of groups	Weight of group at the end of periods	Gains of groups in pounds	Mean gain in weight in pounds per animal
First Period 12-11-45 to 3-28-46					
PK*	3	843.17	1,064.17	221.00	73.7
P	3	796.34	860.34	64.00	21.3
G	3	694.66	730.00	35.34	11.8
Least Significant Difference Between Means:					
At the 5 per cent level					28.14
At the 1 per cent level					46.68
Second Period 4-21-46 to 6-28-46					
PK	3	1,080.84	1,541.16	480.32	160.10
G	3	774.00	1,140.83	366.83	122.30
Least Significant Difference Between Means:					
At the 5 per cent level					143.12
Third Period 8-27-46 to 10-23-46					
PK	6	2,778.16	3,156.34	378.18	63.06
G	3	1,140.83	1,292.33	151.80	50.60
Least Significant Difference Between Means:					
At the 5 per cent level					104.65

*PK—Pará grass-Kudzu mixture.
P—Pará grass alone.
G—Guinea grass alone.

During the first period, the heifers on the mixture plots made significantly better gains than those on the other grasses, as shown in Table 7. A covariance analysis indicated that due to the higher initial weight of the animals in the mixture plots they gained 0.276 pounds more per pound of excess weight than the others. However, the gains were high enough to be significant even after making allowance for this. For the sec-

ond and third periods the gain differences were not high enough to be statistically significant.

At the end of the first period Pará grass was eliminated from the trial because it was severely affected by the drought. Indeed, even before starting the test, it was believed that the place was too high and dry for the Pará grass, which is best grown in low wet soils.

Drought did not seriously affect growth in the mixture plots. A very good mat was formed which could withstand close grazing and trampling and hold more of the moisture in the soil. The probable addition of nitrogen by the legume may have resulted in a better pasture.

Table 2 presents the chemical analyses of the different grasses, the mixture, and the plants from the mixture separately for the whole trial.

No samples were taken from plots that had very little roughage left or were completely grazed out. Samples of the grasses and the mixture were taken as explained before, all through the three periods, but the samples of Kudzu and Pará grass separated from Kudzu were taken in the third period. In all probability this is the explanation of the difference in moisture content and some other of the constituents in the analyses.

TABLE NO. 2

AVERAGE ANALYSES OF THE DIFFERENT GRASSES DURING THE WHOLE TRIAL IN PER CENT, DRY BASIS

Grasses	No. of samples	Moisture Per Cent	Ash Per Cent	Crude Protein Per Cent	Fat Per Cent	Fiber Per Cent	Nitrogen Free Extract Per Cent
Pará grass	9	77 93	8 56	4 01	1 15	33 87	51 53
Guinea grass	15	77 10	12 56	5 76	1 45	32 30	4 10
Pará grass and Kudzu	9	75 55	8 05	10 94	1 76	41 09	46 10
Kudzu alone*	12	77 50	8 14	17 34	2 02	34 21	38 27
Pará alone*	(12)	77 91	9 81	9 00	1 68	30 50	49 00

* Pará grass or Kudzu separated from the mixture.

Kudzu is quite high in protein content and the Pará grass growing with it is higher in protein than when growing alone. The analysis of the mixture presents a more or less intermediate situation showing quite an improvement.

Guinea grass gave a much better analysis than Pará grass alone especially as regard minerals and protein.

The most interesting fact to be observed is the increase in protein content of the Pará grass in the mixture, as compared to the Pará grass growing alone.

The weights of the clippings and the dry matter in pounds for the whole trial are presented in Table 3. The weights of the samples taken for analysis were included.

TABLE No. 3

WEIGHT OF CLIPPINGS AND DRY MATTER YIELDS OF GRASSES; EXPERIMENTAL PLOTS

Grasses	Clippings, lbs.	Moisture Content Per Cent		Dry Matter, lbs.
First Period				
PK	25,382.82	(9 samples)	75.55	5,961.60
P	7,426.57	(9 samples)	77.93	1,639.04
G	9,391.94	(15 samples)	74.10	2,432.51
Second Period				
PK	13,572.73	(same as above)		3,318.53
G	540.52	(same as above)		139.99
Third Period				
PK	2,512.00	(same as above)		614.18
G	248.00	(same as above)		64.23

Larger amounts of forage were clipped from the mixture plots in all the three periods, even with two heifers in the third period.

The data in Table 3 together with the data in Table 1 were used for the calculation of total digestible nutrients and carrying capacity of the three grasses which are presented in Table 4.

The calculations were made according to the recommendations of the Pasture Research Committee of the A.D.S.A. and adapted to our problem. As growing heifers were used in this experiment, some error may have been introduced regarding the nutrient requirements per pound of gain in weight, but it is not felt that this source of error invalidates our conclusions regarding the evaluation of the grasses with respect to their nutritive value and carrying capacity.

The constants used have been as follows:

Standard cow-day = 16 pounds of total digestible nutrients

$$\text{Carrying capacity} = \frac{\text{Standard cow-days per acre}}{\text{Days in grazing season}}$$

Dry matter 72 per cent digestible

3.53 pounds of total digestible nutrients for every pound of gain in weight

The three periods are put together to facilitate comparison.

TABLE NO. 4

CALCULATION OF TOTAL DIGESTIBLE NUTRIENTS AND CARRYING CAPACITY FOR THE THREE PERIODS OF THE EXPERIMENT

Items	First Period			Second Period		Third Period	
	PK	P	G	PK	G	PK	G
1. Days in periods	106	106	106	126	126	67	67
2. Number of heifers	3	3	3	3	3	6	3
3. Total cow-days (1) x (2)	318	318	318	378	378	402	201
4. Total initial weight in pounds	843.17	796.34	694.66	1,050.84	774.00	2,778.16	1,140.83
5. Total final weight in pounds	1,064.17	860.34	730.00	1,541.16	1,140.83	3,156.34	1,292.33
6. Ave. maintenance, lbs. $\frac{(4) + (5)}{2}$	953.67	828.34	712.33	1,301.00	957.42	2,967.25	1,217.08
7. Total weight-days (6) x (1)	101,089.02	87,804.04	75,506.98	163,926.00	120,654.92	198,805.75	81,546.36
8. TDN req. for maintenance, lbs. $\frac{(7) \times 7.925}{1000}$	801.13	695.85	598.39	1,299.11	956.03	1,575.54	646.24
9. Weight gain in pounds	221.00	64.00	35.34	489.32	366.83	378.18	151.50
10. TDN requirement for gain, lbs. (9) x 3.53	780.13	225.92	124.75	1,695.52	1,294.91	1,334.97	534.79
11. TDN requirements, lbs. (8) + (10)	1,581.26	921.77	723.14	2,994.63	2,250.94	2,910.51	1,181.03
12. TDN from residue, lbs.	4,292.35	1,180.11	1,751.40	2,389.34	100.79	442.21	46.25
13. TDN yield of pasture, lbs. (11) + (12)	5,873.61	2,101.88	2,474.54	5,383.97	2,357.73	3,352.72	1,227.28
14. TDN yield per acre, lbs. $\frac{(13)}{\text{acreage}}$	1,957.87	700.63	824.85	1,794.66	785.91	1,117.57	409.09
15. Standard cow-days per acre $\frac{(16)}{(15)}$	122.36	43.79	51.55	112.17	48.99	69.84	25.57
16. Carrying capacity standard cow-days $\frac{(15)}{(1)}$	1.15	0.41	0.49	0.89	0.39	1.04	0.38

The results in Table 4 show the superiority of the mixture over Pará and guinea grasses in total digestible nutrients and carrying capacity. It more than doubles the yields of the other two separately. Guinea grass was similar to Pará in total digestible nutrients and carrying capacity, but was superior from the standpoint of drought resistance.

Taking all the results as a unit the carrying capacity for each grass under the conditions of the experiment were the following:

Mixture of Pará grass and Kudzu	1.02
Pará grass alone	0.41
Guinea grass alone	0.42

Analyses of the yields of total digestible nutrients per acre are presented in Table 5.

TABLE NO. 5

MEAN TOTAL DIGESTIBLE NUTRIENTS YIELDS PER ACRE AND LEAST SIGNIFICANT DIFFERENCES FOR THE GRASSES DURING THE THREE PERIODS

Grasses	TND mean yield in pounds per acre
First Period	
PK	1,957.67
P	700.00
G	842.36
LEAST SIGNIFICANT DIFFERENCES BETWEEN MEANS:	
At the five per cent level	196.49
At the one per cent level	325.87
Second Period	
PK	1,704.89
G	784.03
LEAST SIGNIFICANT DIFFERENCES BETWEEN MEANS:	
At the five per cent level	466.18
At the one per cent level	1,075.27
Third Period	
PK	1,117.65
G	409.47
LEAST SIGNIFICANT DIFFERENCES BETWEEN MEANS:	
At the five per cent level	296.05
At the one per cent level	682.84

The differences between the mean yield of total digestible nutrients per acre among the grasses were statistically significant at the one and five per cent levels for the first and third

periods and at the five per cent level for the second period, in favor of the Pará grass-Kudzu mixture, as shown in Table 6. These results agree with those obtained for carrying capacity.

Summary and Conclusions

Pará grass or "malojillo" (*Panicum purpurascens*), Guinea grass (*Panicum maximum*) and a mixture of Pará grass and tropical Kudzu (*Pueraria javanica*) were tested as pasture crops by rotational grazing of $\frac{1}{3}$ acre plots with native heifers which were 6–7 months of age at the start of the trial.

At the time the heifers were changed from one lot to another, the uneaten portions of the forages were clipped, weighed, and samples secured for chemical analysis. Observations were also made on the ability of the crops to withstand drought, trampling, etc.

Pará and Guinea grasses were similar as measured by gains of the animals, yield and carrying capacity. The Pará grass suffered severely during one phase of the trial due to a drought which affected it unduly because the grass was planted on high, well-drained, soil in contrast to its natural habitat. Guinea grass was not affected by the drought. This resistance plus its other desirable qualities indicates that Guinea grass is suitable as a pasture crop in Puerto Rico.

The combination of Pará grass and Kudzu was found to give the best results in total digestible nutrients, gain in weight of the animals and carrying capacity. There was some evidence to indicate that the mixture benefited the nitrogen balance of the soil and assisted in the retention of precipitation. The Kudzu contained approximately 17 per cent crude protein and Pará grass of the mixture had a higher protein content than that grown alone.

The results of this study indicate that Kudzu is a highly desirable crop to use in conjunction with Pará grass for pasture purposes.

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SODIUM FLUORIDE AS AN ASCARICIDE FOR SWINE RAISED ON THE GROUND

By
By RADAMEE ORLANDI [1] and FERNANDO E. ARMSTRONG.[2]

Parasitism in livestock is one of the major problems encountered by the animal husbandman in Puerto Rico. Swine are seriously affected with ascarides in this island. This is due to several factors some of which are: tropical temperature, relatively high average rainfall (above 70 inches) and, in general, poor management. In Puerto Rico pigs are raised on the ground with no provisions made to avoid or prevent parasitic infestations; and ascarides constitute a constant menace.

Several drugs have been used at one time or another as anthelmintics for swine. Oil of chenopodium has been used extensively since 1918 when Hall and Foster [2] first employed it as an ascaricide. According to Mote [6] its use has been hampered by the difficulty of administration and unreliability in certain cases. Hardwood, Jerstad, and Swanson [3] in 1938, reported on the efficacy of phenothiazine as an anthelmintic for swine. Their results varied from 0 to 100 per cent against ascarides. Phenothiazine has been stated to be an unreliable ascaricide, especially when fed to pigs harboring few ascarides, as reported by Mohler.[5] Swanson, *et al*,[8] reported that the drug is much less effective against immature than mature ascarides.

In 1945, Enzie, Habermann, and Foster,[4] described the use of different levels of sodium fluoride for killing ascarides in pigs. They found that when one per cent sodium fluoride, mixed with the feed, was given to twenty-six hogs, a 100 per cent ascaricidal efficiency was obtained. More recently Turk and Hale,[9] experimenting with large number of pigs, have reported on the ascaricidal properties of sodium fluoride. Their conclusions are based on the number of worms removed and subsequent appearance of the animals submitted to different treatments.

The present experiment was designed to test the value of sodium fluoride as an ascaricide for growing pigs kept on infested grounds and to investigate the possible efficacy of the

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drug to keep animals free from ascarides during their growing period, as well as to observe possible toxicity after repeated treatments.

Materials and Methods

Two trials were conducted to study the ascaricidal effect of sodium fluoride. The first trial also included the use of phenothiazine.

Trial I.—Thirty pigs, ranging in weight from 16 to 34 pounds (averaging 26 lbs.), and about two months of age, were divided into three groups of ten pigs each. The breeding of all groups was similar, litter mates being distributed among the groups in most cases. All of the pigs were kept in a ½-acre-infected lot at all times except when groups "B" and "C" were separated periodically for a few hours for treatment. Individual weights were taken at the beginning and end of the trial. All pigs were self-fed throughout the trial.

Group "A" served as control. Group "B" was weighed every three weeks and given one meal containing 0.2 gm. of phenothiazine per pound of body weight. Group "C" received a treatment of one meal containing sodium fluoride at the rate of 1 pound NaF per 100 pounds concentrate feed, every three weeks.

Trial II.—Was conducted during one year, following Trial I. The conditions were similar except that litter mates were used throughout, sodium fluoride was given at 4-week intervals, and the chances of infection were increased by furnishing a mud wallow.

Egg counts were made per gram of fresh feces secured directly from the rectum of each pig and by using the modified Stoll technique recommended by Hawkins.[4] Except for a short period at the start of the first trial, differential egg counts were made for ascarid and non-ascarid eggs.

At the end of each trial the hogs were slaughtered and visceral examinations made. In Trial I, some pigs from each of the three groups were spared and reincorporated into the breeding herd. One animal of group "A" died soon after the experiment was started.

All data were statistically analyzed by methods outlined by Snedecor.[7]

Experimental Results

The results for Trial I are given in tables 1, 2, 3 and 4.

Although differential counts were not made at the start of the trial, pigs of all groups were shedding ascarid eggs. Total egg counts prior to October 3, 1946 for groups "A", "B" and "C" showed no statistically significant differences. At no time did the numbers of non-ascarid eggs differ statistically among the groups in Trial I. On October 3, 1946 the ascarid egg count for group "C" was statistically significantly lower than for groups "A" and "B". Further statistical treatment for the number of ascarid eggs for Group C was not made as the numbers were so low. At no time did groups "A" and "B" differ statistically in number of ascarid eggs.

The results of the visceral examination are shown for Trial I in table 4. By the use of a chi square test it was found that groups "B" and "C" contained statistically significantly fewer pigs harboring ascarides than group A; and that groups B and C did not differ significantly. As previously mentioned, some hogs from each group were kept for breeding purposes and not slaughtered. As shown in table 2, two of the three hogs of group B, not slaughtered, were casting sufficiently large numbers of ascarid eggs to imply the presence of ascarides in their intestines. The two pigs of group "C" which were not killed were apparently free of ascarides. Thus, the probable numbers of infected hogs for groups "B" and "C" were four and 0, respectively. This apparent difference in the number of pigs dropping eggs is extremely important where the object of the treatment is not only to clear the pigs but to prevent continual reinfection of the ground.

Data collected on growth rates for groups "A", "B" and "C" showed that the mean growth rates for the various groups did not differ significantly.

Trial II.—The second trial gave results similar to those found in the first trial (tables 5 and 6).

TABLE NO. 1

NUMBERS OF ASCARID AND NON-ASCARID EGGS PER GRAM OF FECES IN THE CONTROL GROUP OF TRIAL I (GROUP A)[1]

Pig No.	Total of Eggs Per Gram of Feces			Differential Counts made for Ascarid and Non-Ascarid Eggs Per Gram of Feces									
	8-28-46	9-5-46	9-18-46	10-3-46		10-9-46		10-16-46		10-23-46		10-31-46	
	No. of eggs	No. of eggs	No. of eggs	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.
863	117.0	34.4	35.0	46.0	26.0	29.5	5.0	29.0	5.0	51.5	7.5	52.5	5.5
991	136.0	21.0	139.0	.....	218.5	.....	157.0	1.5	122.5	1.0	120.5	1.0	64.0
883	124.0	74.0	12.0	9.5	12.0	2.5	9.0	1.0	2.5	3.0	4.0	8.5	9.5
908	126.0	69.0	118.0	1.5	4.5	9.0	6.5	11.5	3.0	6.0	1.5	11.0	1.5
903	134.0	175.5	194.0	1.0	84.0	64.5	27.0	67.0	28.0	59.0	13.0	74.0	9.0
935	268.0	115.0	63.0	.....	8.0	.....	4.5	1.0	1.5	0.5	1.0	.....	2.0
960	126.0	83.0	78.5	19.0	14.5	36.5	23.0	25.5	18.5	37.0	12.5	48.0	22.5
979	126.0	115.0	75.0	3.5	45.5	20.5	18.0	15.0	12.5	9.0	19.0	4.0	5.5
984	164.0	83.0	55.0	8.5	43.0	9.0	37.0	6.0	26.5	13.5	34.5	7.5	13.5
941 Died	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	1,315.0	769.9	769.5	89.0	456.0	171.5	287.0	157.5	220.0	180.5	213.5	205.5	133.0

[1] All egg counts should be multiplied by 100.

TABLE No. 2

NUMBERS OF ASCARID AND NON-ASCARID EGGS PER GRAM OF FECES IN THE PHENOTHIAZINE-TREATED GROUP OF TRIAL I (GROUP B)[1]

Pig No.	Total of Eggs Per Gram of Feces[2]			Differential Counts made for Ascarid and Non-Ascarid Eggs per Gram of Feces									
	8-28-46[3]	9-5-46	9-13-46[3]	10-3-46		10-9-46[3]		10-16-46		10-23-46		10-31-46[3]	
	No. of Eggs	No. of Eggs	No. of Eggs	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.
864	181.0	110.0	24.5	4.5	4.5	8.0	1.5	7.0		7.0	1.5	0.5	2.5
877	46.0	28.5	16.0		36.5	0.5	6.5	0.5	6.5		9.0		6.5
886	41.0	26.0	51.5	30.0	48.5	28.5	17.0	26.5	13.0	20.5	10.0	10.5	13.0
912	135.0	53.0	17.5		7.0		3.5		5.0		10.0		2.0
905	98.0	102.5	88.5	39.5	46.0	0.5	20.5		6.5		4.0		3.0
940	381.0	170.5	86.0	3.5	21.0		18.0	0.5	6.0		7.5		5.5
961	226.0	223.5	73.0	36.0	26.0	36.5	18.5	43.0	21.5	21.0	18.0	51.0	31.0
990	55.0	73.0	65.0		225.5		130.0	1.5	36.5	8.5	76.0	10.5	97.0
986	93.0	65.5	158.5	9.5	59.5	23.0	70.5	16.0	40.5	8.5	30.0	14.0	34.0
994	126.0	96.5	96.0	17.5	89.5	13.5	36.5	14.5	83.5	8.5	60.0	19.0	89.5
Total	1,382.0	929.0	676.5	40.5	555.0	110.5	322.5	109.5	219.0	77.0	226.0	105.5	286.0

[1] All eggs counts should be multiplied by 100.
[2] Differential counts not made for number of ascarid and non-ascarid eggs.
[3] Treatment given three days previous to date indicated.

TABLE NO. 3

NUMBER OF ASCARID AND NON-ASCARID EGGS PER GRAM OF FECES IN THE SODIUM-FLUORIDE-TREATED GROUP OF TRIAL I (GROUP C)[1]

Pig No.	Total Eggs Per Gram of Feces[1]			Differential Counts made for Ascarid and Non-Ascarid Eggs Per Gram of Feces									
	8-28-46[2]	9-5-46	9-18-46[2]	10-3-46		10-9-46[2]		10-16-46		10-23-46		10-31-46[2]	
	No. of Eggs	No. of Eggs	No. of Eggs	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.	Asc.	Non-Asc.
865	187.0	170.0	81.5		65.0		56.0		26.5	0.5	15.5	1.0	4.0
881	70.0	43.5	11.5		30.5		9.0		12.0		10.0		4.5
907	105.0	51.5	48.5		27.0	0.5	16.0		3.0		3.0		1.0
899	405.0	400.0	45.0	1.0	167.0	0.5	14.5		10.5		6.0	0.5	12.0
932	75.0	48.0	32.5		23.5		20.5	0.5	14.5		5.5		5.0
957	255.0	69.5	10.5		12.5		18.0		14.5		26.0		22.0
977	82.0	51.0	173.0		77.0		38.0	1.0	23.0		42.0	0.5	31.0
983	85.0	33.0	45.5		35.0		43.0		18.0		20.5		8.0
900	264.0	169.5	23.5		12.5		11.0		4.5		2.5		4.0
876	125.0	19.0	25.5	1.0	5.5		7.5		5.0		3.0		2.5
Total	1,653.0	1,035.0	497.0	2.0	455.5	1.0	225.5	1.5	131.5	0.5	134.0	2.0	94.0

[1] All eggs counts should be multiplied by 100.
[2] Differential counts not made for number of ascarid and non-ascarid eggs.
[3] Treatment given three days previous to date indicated.

TABLE No. 4

NUMBER OF ASCARIS WORMS FOUND IN THE SMALL INTESTINE UPON POSTMORTEM EXAMINATION

Trial 1						Trial 2					
Group A (Control)		Group B (Phenothiazine)		Group C (Sodium Fluoride)		Group D (Control)			Group E (Sodium Fluoride)		
Pig No.	No. of asc.	Pig No.	No. of asc.	Pig No.	No. of asc.	Pig. No.	Female asc.	Male asc.	Pig. No.	Female asc.	Male asc.
863	24	864		865		321	1		321		
883	1	886	3	881		331	1		333		
868	3	912		899		344			341		
903	35	906		883		360	6	3	362		
884	2	980	10	867		384	1	1	381		
905		940		872		385			383		
979	1	877		957		329			320		
				900		335	4		337		
						340	1		349		
						367	3	3	369		
Total	64		13			Total	17	7			

[1] Found with small amount of fibrosis in gastric lobe of liver.

TABLE No. 5

NUMBER OF ASCARID AND NON ASCARID EGGS PER GRAM OF FECES IN THE CONTROL GROUP OF TRIAL II (GROUP D)[1]

Pig No.	Before 1st Treatment		Treatment period																					
	10-8-47		10-15-47		10-22-47		10-29-47		11-12-47		11-19-47		11-26-47		12-3-47		12-10-47		12-17-47		12-24-47		12-31-47		1-14-48	
	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.
323	29.0	15.5	18.0	2.5	13.0	14.0	7.0	32.5	39.0	7.5	17.0	13.5	62.0	27.5	50.5	13.5	69.0	19.5	52.5	12.5	38.5	8.0	1.5	7.0	2.5	3.5
331	21.5	28.0	20.5	27.5	11.0	13.5	20.5	17.5	17.0	35.5	19.0	53.0	27.0	31.0	21.0	25.0	21.0	24.5	20.0	21.5	18.0	23.0	7.0	13.0	8.5	15.5
344		4.5		3.5		9.0		7.0	0.5	19.0	1.5	26.0		12.5		0.5		3.5		3.0		0.5		0.5		10.5
360	4.0	13.5	3.5	0.5	6.0	36.5	5.5	21.0	26.0	55.0	31.0	11.0	57.0	42.5	29.0	2.0	44.0	25.5	38.0	17.0	35.5	8.0	67.5	7.5	40.0	3.0
384	1.0	17.5	0.5	3.5	3.5	16.5	12.0	19.5	13.0	37.0	6.0	19.0	18.0	40.5	10.0	7.5	13.0	20.5	21.0	39.0	20.5	28.5	17.0	4.0	9.0	5.0
385		141.0		7.0		51.5		19.0		6.0	0.5	7.0		9.0		4.0		13.0		6.0	0.5	7.0		2.5		7.0
329		3.0		0.5		2.5	0.5	6.0		5.0				2.5	2.0	1.5		8.0	1.0	1.0		2.5	0.5	2.0		2.5
335	20.5	15.5	6.0	2.5	9.5	34.0	10.5	11.5	31.0	33.5	25.0	32.5	57.0	42.0	28.0	15.5	22.0	9.0	32.5	13.5	27.0	6.5	5.0	4.5	12.5	15.0
340		22.0			0.5	15.5		11.5		11.5		2.5		23.0	0.5	5.5		7.5	1.5	22.5	3.5	8.5	1.5	1.0	4.0	12.5
365	87.5	10.5	79.0	0.5	69.5	6.0	37.0	1.5	62.0	4.0	46.0	19.0	84.0	13.5	44.0	3.0	57.5	31.5	55.5	11.5	60.5	12.5	66.0	16.0	45.0	15.5
Tot.	163.5	269.0	127.5	48.0	113.0	199.0	93.0	138.0	188.5	214.0	146.0	183.5	285.0	244.0	185.0	78.0	226.5	162.5	222.0	147.5	204.5	105.0	166.0	58.0	121.5	90.0

[1] All egg counts should be multiplied by 100.

TABLE NO. 6

NUMBER OF ASCARID AND NON-ASCARID EGGS PER GRAM OF FECES IN THE SODIUM FLUORIDE-TREATED GROUP OF TRIAL II (GROUP E)[1]

Pig No.	Before 1st Treatment		Treatment period																					
	10-8-47		10-15-47[2]		10-22-47		10-29-47		11-12-47[2]		11-19-47		11-26-47		12-3-47		12-10-47[2]		12-17-47		12-24-47		12-31-47		1-14-48[2]	
	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.	Asc.	Non-asc.
321	30.5	35.5	1.0	8.5	2.0	33.5	4.5	5.5		61.0		72.0		23.0		3.5	0.5	8.5		10.0		8.5		7.0		2.5
333	5.0	5.5		3.5		6.5		10.0	1.5	23.0		23.5	0.5	22.5		8.0	0.5	19.0	0.5	11.0		16.5		12.0		17.0
341	3.0	1.0		5.5		3.5		1.0		8.0		5.0		10.5		8.5		5.0		3.5		5.0		1.0	0.5	13.5
362	16.5	24.0		6.0		12.0	0.5	11.0	0.5	25.0	1.0	18.5		18.5	1.0	8.5		32.5	1.0	19.0	0.5	18.5		10.0		11.0
381		23.5		7.5		16.0		15.5	1.0	24.0		25.0		12.5	0.5	15.0		8.5		11.0		9.5		12.5		19.0
386	1.0	24.0		19.0		41.0		61.0	0.5	55.5		6.5	0.5	25.0		9.0		23.5	0.5	6.5		11.0		8.5		11.0
320	8.5	7.5		3.5		3.0		2.5		13.0		6.5		6.0	0.5	1.5		3.0	0.5	8.5	0.5	5.5	0.5	7.5		6.0
337	75.5	8.0	4.0	5.5		1.5		3.0		13.5	0.5	6.0		2.5	0.5	1.5		5.5	0.5	2.5		5.0		7.5		2.5
349		30.0		15.0		15.0		12.5		20.0		12.0		5.0		2.5		5.0		6.5		2.0		5.0		5.0
369	26.5	7.5		1.0		8.5		9.5	1.0	18.5		2.5		17.0	1.0	11.0	1.0	17.5	1.5	10.5	2.0	17.5	2.2	5.0		5.5
Tot.	166.5	166.5	5.0	75.0	2.0	140.5	5.0	133.5	4.5	261.5	1.5	177.5	1.0	142.5	3.5	69.0	2.0	128.0	4.5	89.0	3.0	99.0	2.7	76.0	0.5	92.5

[1] All egg counts should be multiplied by 100.
[2] Treatment given three days previous to date indicated.

Prior to the first treatment with sodium fluoride, there were no statistically significant difference in either ascarid or non-ascarid egg counts between groups "D" and "E". The data for total ascarid eggs from the time treatments were started to the end of the experiment, exhibited a highly significant difference between the sodium-fluoride-treated and the control pigs (tables 5 and 6). On the other hand, the data for total non-ascarid eggs of the sodium-fluoride-treated and control groups collected during the same period (treatment period) showed no statistically significant difference between the two groups.

Upon slaughter, the small intestines of the sodium-fluoride-treated animals (group "E") were found free of ascarid worms, while seven of the ten control pigs (group "D") were infested with a total of 24 ascarides (table 4). All viscerae (groups "E" and "D") were found normal except one pig in group "D" (pig No. 365) which had a small amount of fibrosis in the gastric lobe of the liver. This pig, as will be noticed from table 5, shed the highest number of ascarid eggs throughout the experimental period.

Data were also collected for the growth rate of the two groups studied in this second trial. The growth rates were similar to those obtained in Trial I. The difference in the rate of gain between groups "D" and "E" was statistically non-significant.

Discussion

The results obtained demonstrate that the pigs given sodium fluoride were apparently free of ascarides for the duration of the trials as ascertained by differential egg counts. Upon slaughter, they were found to be free of ascarides. The ascarid eggs found in the feces of some treated animals were nonembryonated eggs and were probably eggs that were engulfed in the noninfective stage.

Phenothiazine did not exhibit satisfactory ascaricidal properties as shown by the egg counts of table 2 and the recovery of adult worms from the small intestines as shown in table 4. Phenothiazine, in the concentration used, did not prevent infection as shown by pig No. 980 (table 2) which, although free of ascarid eggs on October 3 and October 9, indicated an increasing amount of eggs shed up to the end of the trial and which was found to have ten adult worms when slaughtered.

In addition, a study of the data of table 2 indicates that the phenothiazine did not consistenly lower the number of ascarid eggs.

The data secured in this study indicate that sodium fluoride is a more satisfactory ascaricide than phenothiazine, at the dosage used. The sodium fluoride proved effective after one treatment. This was shown by the data collected for the number of ascarid eggs shed before and after the first treatment (see ascarid egg counts on October 8 and October 15, 1947 in table 6). No injurious or toxic effects treatment (see ascarid egg counts on October 8 and October 15, 1947 in table 6). No injurious or toxic effects were noted when the use of the one-per-cent mixture with the feed was given every 3 or 4 weeks for periods of 3 to 4 months. Weight gains were not affected by the drug treatments: the control and the sodium-fluoride-treated pigs made similar weight gains. Sustained use of the drug kept the pigs free of adult worms. This is of invaluable advantage where lots are heavily infested and poor management practices prevail. First, there will be fewer adult parasites living at the expense of the feed provided for the growing pigs and secondly, there will be a progressive decrease of chances of infection as a result of having progressively fewer fertile eggs deposited upon the ground.

In relation to the parasitic organisms present, sodium fluoride seemed to be a specific for ascarides. No differential counts were made for non-ascarid eggs but the following types were the most commonly found: *Strongyloides*, *Oesophagostomum*, *Hyostrongylus*, *Globocephalus* and *Trichuris*. As the number of these eggs did not decrease as the result of treatment, the sodium fluoride presumably had little or no effect on those organisms.

It may also be stated that in addition to being a reliable ascaricide, sodium fluoride is very economical to use and easy to administer. The mixture of feed and sodium fluoride was found to be palatable.

Summary and Conclusions

Two trials were conducted to test the value of sodium fluoride as an ascaricide for growing pigs kept on infested grounds. The ability of the drug to kep animals free from ascarides and the possible toxicity upon repeated treatment were also studied.

Three groups of animals similar as to breeding, weight and age were used in Trial I. Group "A" served as control. Group

"B" received 0.2 gm. of phenothiazine per pound or bodily weight and group "C" one per cent sodium fluoride mixed with ground feed. Except for slight variations in the procedure and the elimination of the phenothiazine treatment, Trial II was conducted in the same manner.

The effectiveness of the different treatments given during the experimental period was measured by statistical analyses of the number of ascarid and non-ascarid eggs per gram of fresh rectal feces secured once every week, by the weight gains made by each animal, and by the number of *Ascaris* worms found upon visceral examination.

The results obtained suggest that sodium fluoride at the rate of one per cent mixed in the feed every three weeks is a very satisfactory drug for killing *Ascaris lumbricoides suis* found in growing pigs raised on the ground. When fed repeatedly to growing pigs for periods of from 3 to 4 months it was effective in keeping the animals clean, with no toxic effects whatsoever.

Phenothiazine at the rate of 0.2 gm. per pound of bodily weight administered every three weeks was found to be unreliable as an ascaricide.

The data obtained during the two trials made suggest that sodium fluoride is specific against *Ascaris lumbricoides suis*.

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THE USE OF CANE MOLASSES AS PART OF THE CONCENTRATE DAIRY RATION USING MERKER GRASS AS ROUGHAGE

By

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INTRODUCTION

"Only that dairyman can succeed who feeds his cows both economically and efficiently".[6]

Intensive milk production in Puerto Rico is generally dependent upon concentrate feedstuffs. Most of these feedstuffs are imported from the United States at prices which represent more than 50 per cent of the cost of milk production. The total value of dairy feeds imported to the Island during 1945–1946 [2] was almost four million dollars.

During 1945–1946, Puerto Rico produced around 38.5 million gallons of molasses. Of this, a large amount was used by the rum industry or exported, and very little was used as livestock feed.

In the United States, molasses is added to high-grade mixed feeds on account of its palatability, and also because it is one of the cheapest of readily digestible carbohydrates.[14] In the past, feeds containing molasses were imported to the Island and dairymen were paying an excessive price for the molasses put into the feed. Due to the fact that in tropical climates molasses undergoes fermentation under prolonged storage, the importation of molasses-containing feeds was discontinued.

As Puerto Rico is a sugar-cane growing country, molasses should be an economical substitute for part of the grain in feeding dairy cows and other livestock on the Island.

LITERATURE REVIEW

Ellison and Varas Catala,[7] in Puerto Rico, supplemented the grain ration of one group of cows with cane molasses and of another group with corn chops,* and used cane as the only

* Corn chops—corn and cob chopped.

[1] Associate Animal Husbandman.

[2] Assistant Animal Husbandman

[3] Assistant Chemist.

roughage. The chopped-corn lot consumed more feed and produced more milk, but the greater economy in cost of milk production resulted when the molasses was added to the ration. Labh Singh and Sahi Gambhir [12] found that for feeding bullocks in India molasses could replace corn pound for pound.

McComas et al.[13] said that on the basis of average data for four experiments using Herford steers in terms of live-weight produced, the corn-molasses mixture in the ratio of 1 to 1 was approximately 80 per cent as efficient as corn, whereas the mixture in the ratio of 3 to 1 was approximately 90 per cent as efficient. Britnal [6] feeding dairy cattle in Mississippi, stated that, practically one pound of molasses was equal to one pound of corn. Morrison [14] cites two Wisconsin experiments where 10 per cent of cane molasses was incorporated into a mixture of palatable concentrates; the milk production was practically the same as on the concentrate mixture without molasses. In these trials, the molasses was worth 89 per cent as much per pound as ground corn.

Bary et al.[3] found, for fattening steers, that molasses had a calculated value of 85 per cent that of corn. In individual tests, the value ranged from around 85 per cent up to better than 100 per cent of the value of corn. Their experiments indicated that molasses was used most efficiently when fed at around 3 to 4 pounds per head daily.

Experimental studies and practical experience with dairy cattle at the Missouri Station [1] showed that molasses may satisfactorily replace $^1/_4$ to $^1/_3$ of the ground corn. Usually not more than two to three pounds of molasses should be fed daily per 1000 pounds of live weight.

Skinner and King,[17] feeding cattle in Indiana, came to the conclusion that the advantage of feeding molasses arose from its low cost rather than from the feeding value. The nutritive value of molasses was slightly lower than an equal weight of corn as measured by the rate of gain and finish of the cattle.

Snell et al. [15] at Louisiana, found that molasses was equivalent to corn grain as a feed for working mules. Their early experiments indicated that molasses is only slightly less valuable than corn pound for pound as a feed for dairy cattle.

It was found in Hawaii, in experiments conducted by Henke [10] covering a period of seven years, that when properly supplemented with protein-rich feeds, cane molasses could be satisfactorily substituted for one quarter of the concentrate usually

fed dairy cows. The use of molasses did not affect the reproductive efficiency or increase abortions. Henke emphasizes the importance of using more molasses in the dairy rations due principally to differences in price. Willet et al.,[19] in another series of trials in Hawaii, stated that pigs, from time of weaning until they reach a weight of 60 to 70 pounds, can utilize cane molasses effectively up to levels of 20 per cent of the ration. There was no appreciable difference in the amount of total digestible nutrients required per pound of gain. The data indicate that molasses is equal to barley when fed at these levels and when compared on total-digestible-nutrient basis. The feed cost per pound of gain decreased with the increase in the amount of molasses fed. When molasses was fed at levels of 30 to 40 per cent of the rations, the rate of gain and efficiency in the utilization of feed or the total digestible nutrients decreased markedly. The accompanying diarrhea was another factor that affected the utilization of the high molasses rations.

Ott et al.[15] used molasses in poultry rations and stated that the use of molasses up to six per cent in the rations substituting corn depends upon the prices of both corn and molasses. Brigs et al.[3] working with lambs said that the results of a limited amount of work on the tolerance of lambs for blackstrap molasses indicated that lambs can utilize the product at a level of 10 per cent of the ration more efficiently that at a level of 25 per cent. They[4] noted that in two digestion trials in which eight lambs were used, substitution of blackstrap molasses for at least one half of the corn in a lamb-fattening ration lowered the coefficient of apparent digestibility for protein, fat and nitrogen-free extract in appreciable amounts. On the other hand, Williams[20] said that the data of his experiments indicated that the digestibility of the crude fiber, the nitrogen-free extract, and the ether extract was not uniformly affected in either direction by the presence of molasses in the ration. He agrees with Brigs and Heller[3] in the fact that molasses tends to depress the digestibility of crude protein and dry matter; however, he adds that this depression is so slight that it would scarcely be appreciable in ordinary feeding practices.

Kraus[11] at Ohio, found that cane molasses as a supplement to milk for rats produced excellent growth, prevented nutritional anemia, and was of value for haemoglobin regeneration in anemia. Beet molasses did not prevent anemia and had no beneficial effects on rats suffering from nutritional anemia. Chemical

analyses showed that cane molasses contained larger quantities of iron and copper than did beet molasses.

Molasses seems, therefore, to have a well-defined position as a feed for livestock. Its value has been compared with corn in many different experiments. In conclusion, it can be said that its value ranges from 80 to 100 per cent of the value of corn or other carbohydrate feed and the variation depends on the proportion which is used in the mixture. For dairy cows care should be taken to maintain the protein content of the mixture at an adequate level to prevent harmful effects on milk production.

Experimental

Eighteen cows divided in three groups of six each were used in the experiment. The groups were balanced according to the stage of lactation period and milk production. All the cows were giving over eight pounds of milk daily and none was over ten months in lactation. Except for four purebred Holstein cows, all cows were Holstein-Native crossbreds with varying amounts of Holstein blood.

The experiment consisted of a single reversal trial using the groups as follows: After a five day pre-feeding period, the first group was fed regular Merker grass and regular 20 per cent protein concentrate ration at a level of 1 pound of concentrate for every 2.0 pounds of milk. A narrow ratio of feed to milk was used to compensate for the lower quality of the roughage. The second group was fed the same kind of grass but the concentrate ration consisted of four parts of regular 20 per cent protein concentrate feed and one part of cane molasses. The third group was fed young Merker grass plus the molasses-concentrate ration. The first part of the experiment lasted for 18 days, pre-feeding excluded.

For the second part of the experiment, the first two groups were switched on the concentrate rations. The third was fed the regular mature Merker grass pus the molasses-concentrate ration. The second part of the experiment lasted for 17 days, pre-feeding excluded.

The cows were weighed for three consecutive days at the beginning of the experiment, at the end of the first part and at the end of the second part of the experiment. Roughage consumption and milk records were kept daily for each individual cow. Forage samples for moisture content were gathered twice a week. These samples were dried in an oven at 70°C.

The molasses was mixed with the feed by spreading the feed on a concrete floor and sprinking the molasses over it as evenly as possible. Two men with shovels mixed the concentrate feed and molasses thoroughly. The mixing was done this way due to the fact that the majority of the dairies in the Island do not have mixers to mix the ingredients. Enough feed was mixed every time for two or three days.

The milk production of the animals in the different groups depended on a number of factors, among which the ration fed, the stage of lactation, and individual differences between the animals may be mentioned. In order to determine the effects of the differences in the rations fed on the milk production of the different groups, a regression equation was adapted to the milk production figures. The equation constants represent the differences in milk production due to differences between the rations fed and to the effect of the stage of lactation.

Fitting of the regression equation and calculation of the standard error of the constants were made according to the methods described by Snedecor.[16] Difference in roughage consumption as well as weight differences were also studied.

RESULTS

Milk production for the experimental periods is presented in table 1. Pre-feeding periods were excluded.

TABLE No. 1

MILK PRODUCTION IN POUNDS FOR ALL ANIMALS DURING THE EXPERIMENTAL PERIODS*

Name of Cow	Ration No. 1	Ration No. 2	Ration No. 3
	Second Period	First Period	
Vera	149.2	176.9	.....
Nana	93.6	151.2	.....
Lupe	368.2	395.9	.....
Carmelita	321.1	325.8	.....
	First Period	Second Period	
Laura	184.7	192.8	.....
Soroca	502.0	493.0	.....
Walker	287.0	158.3	.....
Nellie	322.2	285.9	.....
Rivera	376.6	366.9	.....
		Second Period	First Period
Toledo		164.0	192.7
Mulata		82.2	121.8
Dumore Jr.		264.4	305.0
Luisa		283.8	362.3
Maria		286.9	343.1
Coamo		214.3	372.6

* Three cows were not able to finish in the experiment due to sickness; they were not included in the comparisons.

Ration No. 1—cows on regular Merker grass and concentrate alone.
Ration No. 2—cows on regular Merker grass and molasses-concentrate.
Ration No. 3—cows on young Merker grass and molasses-concentrate.

The constants of the fitted equation and their respective standard errors are as follows:

	Constants	S. E.	Meaning of Constants
A	7.65	15.38	Difference in production due to rations 2–1
B	−36.26	24.31	Difference in production due to rations 1–3
C	32.27	15.38	Difference in production due to periods 1–2

The above constants are subject to twelve degrees of freedom and none of them is, therefore, significant. Thus, the evidence available does not indicate any superiority of the 100 per cent concentrate feed as against 80 per cent concentrate feed and 20 per cent molasses or vice versa.

Molasses did not have any significant depressive effect on milk production when used as a substitute of the concentrate ration to the extent of 20 per cent. On the other hand the molasses has definite advantages that will be discussed later on.

TABLE No. 2

SUMMARY OF ROUGHAGE CONSUMPTION BY GROUPS

No. of cows	Ave. wgt. pounds	Average pounds consumed	Average per cent dry matter	Average D. M.[1] consumed daily	D. M. per[2] 100 pounds L. W.[2]	Ave. wgt. pounds	Average pounds consumed	Average per cent dry matter	Average D. M. consumed daily	D. M. per 100 pounds L. W.[2]
	First Period					Second Period				
	Regular Merker grass molasses concentrate					Regular Merker grass no molasses concentrate				
4	941	1,276.00	28.00	20.00	2.13	917	1,299.00	28.00	21.00	2.36
	Regular Merker grass no molasses concentrate					Regular Merker grass molasses concentrate				
5	1,033	1,171.00	28.00	18.00	1.78	1,012	1,280.00	28.00	21.00	2.11
	Young Merker grass molasses concentrate					Regular Merker grass no molasses concentrate				
6	891	1,445.00	25.00	20.00	2.26	878	1,203.00	28.00	20.00	2.28

[1] D. M. dry matter.
[2] L. W. live weight.
[3] In checking, results may not agree with data due to the fact that figures were rounded in the table.

Although this was a short time experiment, the results were similar to those obtained by Henke [10] in Hawaii, in a seven-year period, and by other workers.

The average amount of roughage consumed during the experimental periods by each group of cows is presented in table 2.

Except in the case of the second group in the first experimental period, the average dry matter consumed per 100 pounds of live weight during the course of the experiment showed very little difference, indicating a more or less equal intake of nutrients from the roughage. When the data were treated statistically, they showed no significant differences among the groups.

Variations in bodily weight during the experiment are shown in table 3.

TABLE NO. 3

WEIGHT LOSSES DURING THE COURSE OF THE EXPERIMENT

Group No.	No. of cows	Average loss in weight by groups, in pounds	Average loss per cows in pounds
1	4	98.00	24.50
2	5	105.00	21.00
3	6	52.00	8.66

As shown by the average weight lost per cow in the 44 days of experiment (pre-feeding periods included) they practically maintained their initial weights throughout. No statistically significant difference was found among the groups.

Discussion

Molasses has been always the cheapest source of carbohydrate food in Puerto Rico. An illustration of this is presented in table 4, where prices for an eleven-year period are compared.

Table No. 4

RETAIL PRICES FOR MOLASSES AND 20 PER CENT PROTEIN DAIRY FEED 1938 TO 1948

Year	Molasses Drums of[1] 54 gallons, 650 lbs.	Price of molasses, per 100 pounds	Price of 20% protein[2] dairy feed, per 100 pounds
1938	$1 62	$0 25	$1 95
1939	1 62	0 25	2 10
1940	2 70	0 42	2 24
1941	2 70	0 42	2 41
1942	5 13	0 79	3 61
1943	2 50	0 38	3 48
1944	6 48	1 00	3 79
1945	7 34	1 13	3 64
1946	7 34	1 13	4 25
1947	8 37	1 29	4 81
1948	12 04	1 85	5 48

[1] Personal, communication of the Administrator, Central San José, Río Piedras, July 1948.
[2] Personal communication of the Manager, Sociedad Agrícola Cooperativa, San Juan, Puerto Rico, July 1948.

A real saving will be attained due to the difference in prices, plus other advantages such as those of adding palatability and flavor to the ration. A simple way of calculating the saving by the use of molasses as 20 per cent of the concentrate ration is as follows.

Actual cost of 100 pounds of 20 per cent total protein dairy feed	$5. 50
Actual cost of 100 pounds of molasses	$1. 85
Cost of 80 pounds of 20 per cent dairy feed	$4. 40
Cost of 20 pounds of molasses	$0. 37
Cost of one hundred pounds of the mixture	$4. 77

In the above example there will be a saving of 73 cents or 13 per cent of the cost of the feed, due to the use of molasses. The net income will be a little less due to the labor used in the preparation of the mixture. Using 1945–46 figures, which show that the Island imported around four million dollars of concentrate feeds, the savings will amount to one-half million dollars.

At this point of the discussion two questions arise. Does the addition of that amount of molasses appreciably affect the percentage of total protein in the mixture?, and, do the cows get adequate amounts of protein from that mixture for normal milk production? Using molasses at a rate of 20 per cent of the

concentrate feed the percentage of protein in a 20 per cent protein concentrate mixture is lowered, theoretically, to 16 per cent. The results of the experiment indicated that the milk production was normal.

Extensive work conducted at the New York (Cornell) Station [8] has shown that very little difference in milk production is to be expected when feeding concentrates containing 16 per cent and 20 per cent protein at the conventional ratio of one pound of feed to three and one half pounds of milk, using Timothy-clover mixed hay and corn silage. Further studies at Ithaca [9] indicated that a very small increase in milk production could be expected from a 20 per cent total protein concentrate as compared to the 16 per cent total protein concentrate, but this increase in production is not large enough to warrant the purchase of a 20 per cent total protein over a 16 per cent if the cost of the 20 per cent is greater.

Experiments conducted at this Station (J. I. Cabrera, unpublished results) showed no significant difference in production when a 16 per cent total protein mixture was compared to a 20 per cent, using ratios of one pound of feed to two pounds of milk or a ratio of one to three respectively. In a second experiment, 20 and 24 per cent total protein mixtures were better than the 16 per cent. Henke [10] stated that using protein-rich feeds, molasses can be substituted for 25 per cent of the mixture.

These results show that dairymen in Puerto Rico and farmers in general should be using molasses on a larger scale as feed for livestock. Its nutritive value has been known for years, (see literature review). The Island produces a large amount of it most of which is sold abroad, due to a lack of acceptable prices in the local market. If the usage of molasses becomes general throughout the Island, both cane-growers and dairymen will benefit.

Summary and Conclusions

Two groups of cows were fed regular Merker grass soilage, 20 per cent protein concentrate, and a mixture of four parts of a 20 per cent protein concentrate plus one part molasses in a switch-back feeding trial. A third group was fed young Merker grass for the first part of the experiment, and regular Merker grass for the second part, plus the molasses-concentrate ration with each grass.

Statistical analysis of the data indicates that molasses did not have any depressive effect on milk production. The amount of dry matter in roughage consumed per 100 pounds of live weight was essentially the same for all groups; the difference was statistically non-significant. Although body weight was not maintained throughout the experiment, the difference in weight lost among groups was not statistically significant.

Due to the difference in price between molasses and the mixed dairy feeds, the use of molasses can effect considerable saving to the farmer who uses it as part of the concentrate ration. It can be substituted for 20 per cent of the concentrate ration and probably more.

As Puerto Rico is a sugar cane producing area, molasses should be used locally to a greater extent as a livestock feed. It is readily available and is the cheapest source of carbohydrates on the Island.

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